STRUCTURAL DESIGN – I

02. PROPERTIES OF INGREDIENTS OF CONCRETE

KIRAN S R

Lecturer

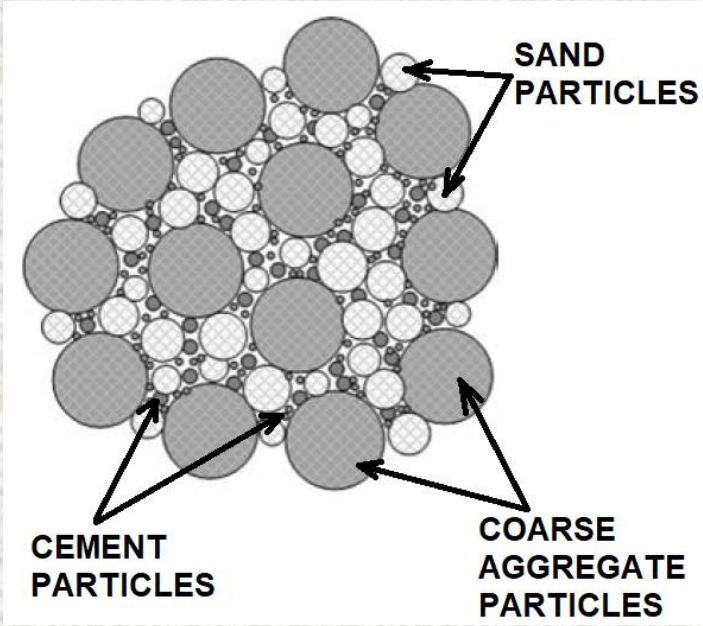
Department of Civil Engineering

Central Polytechnic College Trivandrum

INGREDIENTS

Concrete consists of the following ingredients:

- **Cement** – Binding material; Micro-void filler
- **Fine Aggregate** – Void filler (use Sand)
- **Coarse Aggregate** – Strength provider (use Hard blasted granite chips)
- **Water** – Hydrates cement; Controls workability and strength
- **Admixture** – modifies the properties of concrete in fresh and hardened state



1. CEMENT

- Raw Materials: Calcareous (limestone) & Argillaceous (clay) materials
- It contains the following oxides: CaO, SiO_2, Al_2O_3, Fe_2O_3, MgO, SO_3, Alkalies (K_2O, Na_2O)
- Mixed in 4:1 ratio
- It is fed into a rotary kiln and blasted at 1500^oC.
- Clinker (of nodular shape) is obtained, which is cooled and ground into fine powder.
- To this 3-5% Gypsum is added to prevent quick setting of cement.
- The cement, thus obtained, contains four major compounds known as *Bogue's Compounds*:
  - ❑ tricalcium silicate (C_3S) ~ 50% by volume of cement
  - ❑ dicalcium silicate (C_2S) ~ 25%
  - ❑ tricalcium aluminate (C_3A) ~ 15%
  - ❑ tetracalcium aluminoferrite (C_4AF) ~ 10%

- **Hydration of cement:** When Cement mixed with water, the Bogue's compounds react with water and heat is liberated (Exothermic Reaction). This heat is called Heat of Hydration.
  - Order of hydration: C_4AF & C_3A, C_3S, C_2S
- **Grades of cement:** Cement is available in 3 grades:
  - 53grade cement
  - 43grade cement
  - 33grade cement

  where 33, 43, & 53 represents the minimum average 28-day compressive strength of 3 cement-mortar cubes

2. AGGREGATES

Fine Aggregates

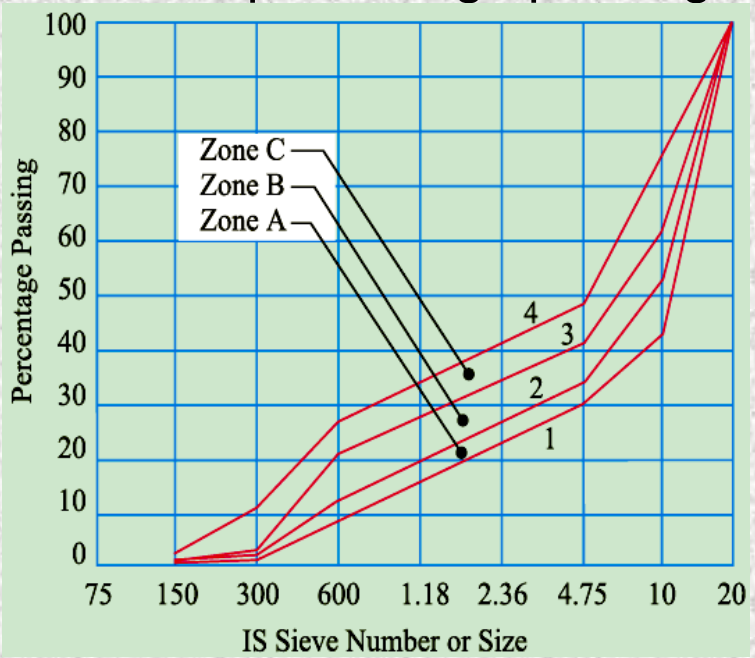
- particle size between 0.075mm and 4.75mm
- generally used – river sand, manufactured sand

Coarse Aggregates

- particle size > 4.75mm
- generally used – Hard blasted granite chips
- The nominal maximum size of aggregate should be < $(1/4)^{th}$ the minimum thickness of the member
- In case of heavily reinforced sections, nominal maximum size of aggregate should be the smaller of:
  - Clear distance between bars minus 5mm
  - Minimum cover to reinforcements minus 5mm

Grading of Aggregates

- ‘Grading’ is the particle size distribution of aggregate
- measured by *sieve analysis*, and is generally described by means of a *grading curve*, which depicts the ‘cumulative percentage passing’ against the standard IS sieve sizes.
- Figure shows, standard grading curves 1, 2, 3 and 4 are shown (plotted per IS383). The particle size distribution of the given sample of aggregates shall conform to any of the zones A, B or C.
- Curve 1 represents the coarsest grading, while curve 4 represents the finest grading.



The ease with which concrete can be mixed, placed, compacted and finished.

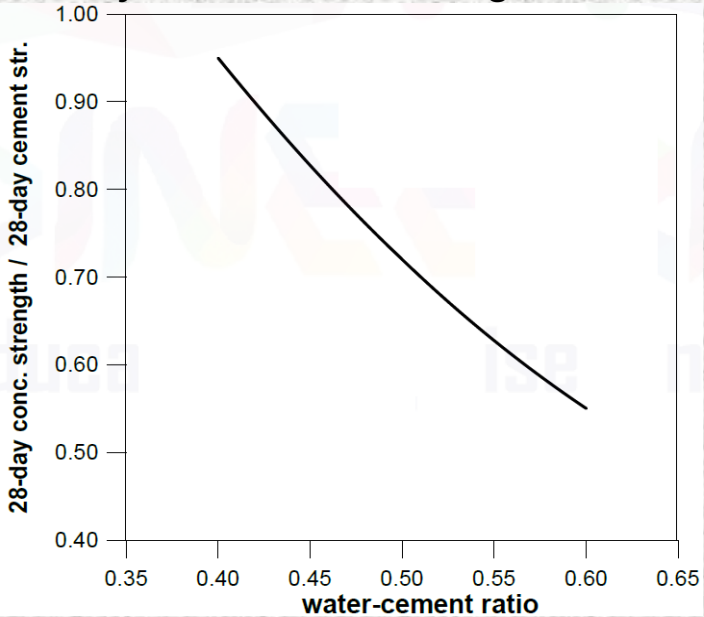
- The grading (as well as the type and size) of aggregate is a major factor which influences the *workability* of fresh concrete, and its consequent degree of *compaction*.
- This is of extreme importance with regard to the quality of hardened concrete, because incomplete compaction results in *voids*, thereby lowering the *density* of the concrete and preventing it from attaining its full compressive strength capability; furthermore, the impermeability and durability characteristics get adversely affected.
- Presence of more “fines” (i.e., cement & sand) in a concrete mix would improve both workability and resists segregation (**segregation means separation of grout from aggregates in a concrete mix due to addition of excess water to concrete**)

3. WATER

- For mixing of fresh concrete
- For curing of concrete, while hardening
- Water used for concrete should be potable
- Use of seawater for mixing or curing of concrete is not recommended due to the presence of harmful salts
- Generally, water content used in concrete is 180-200 L / m^3 of concrete.

Parameters	Permissible limit
pH	≥ 6
Organic	< 200 mg/L
Inorganic	< 3000 mg/L
Sulphate	< 400 mg/L
Chlorides	< 500 mg/L for RCC; < 2000 mg/L for PCC
Suspended solids	< 2000 mg/L

- Excess water in concrete tends to rise up to the surface of the mix, as the solid constituents settle downwards. This is called Bleeding.
- **Abrams' Law:** Compressive strength of hardened concrete is inversely proportional to the water-cement ratio. A reduction in water-cement ratio generally results in an increased quality of concrete, in terms of density, strength, impermeability, reduced shrinkage and creep etc.



ADMIXTURES

- Added to concrete to modify its properties in fresh & hardened state
- Broadly, two types
  - ❑ Chemical Admixtures (liquid in form)
  - ❑ Mineral admixtures (fine granular in form)

Types of Chemical Admixtures

- *Accelerators* – accelerates the hardening process (early strength development)
- *Retarders* – delays the setting of concrete, to reduce the heat generation
- *Superplasticizers* – high range water reducers; increase flowability without increasing water content; produce high strength concrete
- *Air-entraining Agents* – introduce microscopic air bubble cavities in concrete; minimize damage due to alternate freezing & thawing
- *Bonding admixtures* – used to improve adherence of fresh concrete to old concrete

- **<u>Types of Mineral Admixtures (Puzzolonas)</u>**
  [Cl. 5.2 of IS456] – Mineral admixtures are generally used as partial replacement of cement in concrete. They react with Calcium hydroxide in the presence of water to form cementitious compounds.
  - *Fly Ash*
  - *Ground Granulated BlastFurnace Slag (GGBS)*
  - *Silica Fume*
  - *Rice Husk Ash*
  - *Metakaoline*